ESE-Q-74
July 8, 1966

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

QUALIFICATION TEST REPORT

POLYURETHANE ELASTOMERIC COMPOUND

CPS 796-80, TYPE III

EQUIPMENT PRODUCTION AND EVALUATION SECTION
ELECTRICAL SUPPORT EQUIPMENT BRANCH
ASTRIONICS LABORATORY
National Aeronautics and Space Administration

NASA

FORM NO. 1A 9-62

REPORT SUMMARY SHEET

1. COMPONENT PART NAME PER GENERIC CODE
Material; nonmetallic, encapsulating, extrusion, thermally insulative

2. PROGRAM OR WEAPON SYSTEM
Saturn IB & Saturn V

3.

	DAY	MO	YR.
TEST COMPL.	28	7	65
REPT. COMPL.	8	7	66

4. ORIGINATOR'S REPORT TITLE
Qualification Test Report, Polyurethane Elastomeric Compound CPS 796-80, Type III

5. ORIGINATOR'S REPORT NO.
ESE-Q-74

6. TEST TYPE, ETC.
Qualification testing to Specification MSFC-SPEC-202A

7. THIS TEST (SUPERSEDES) (SUPPLEMENTS) REPORT NO:

ITEM	8A. PART TYPE, SIZE, RATING, LOT, ETC.	9. VENDOR	10. VENDOR PART NO.	11. IND./GOV. STD. NO.	12. TOTAL TESTED
1	Polyurethane elastomeric compound, type III	Coast Pro-Seal & Mfg. Co.	CPS 796-80		
2					
3					
4					(OVER)

13. INTERNAL SPECS ETC REQ'D TO UTILIZE REPT.	ENCL	SENT WITH REPORT NO.	14. MIL. SPECS./STDS. REFERENCED IN 15C
A MSFC-SPEC-202A			D
B			E
C			F

15A ITEM	TEST OR ENVIRONMENT	C PER SPEC	D SPEC. PARAGRAPH METHOD/CONDITION	E TEST LEVELS, DURATION AND OTHER DETAILS	F NO. TESTED	G NO. FAILED
All	Dielectric constant & power factor	A	4.4.3.1	Maximum null dip with specimen inserted in a micrometer-driven dielectric sample holder.	3	0
All	Dielectric strength	A	4.4.3.2	Test voltage increased from zero to breakdown 500 Vps on each of 5 specimens.	5	0
All	Volume resistivity	A	4.4.3.3	Three electrode guarded circuits 500 Vdc megohm bridge at 24° C.	3	0
All	Surface resistivity	A	4.4.3.3	Three electrode guarded circuit, 500 Vdc megohm bridge at 24° C.	3	0
All	Arc resistance	A	4.4.3.4	High voltage, low current arc automatically applied in time interrupted steps.	3	0
All	Insulation resistance	A	4.4.3.5	500 V for 2 minutes @ 24 and 100 ± 1° C	3	0
All	High potential	A	4.4.3.6	1000 V rms at 60 Hz for 1-min period.	3	0
All	Low temperature flexibility	A	4.4.3.7	-55 ± 1° C for 4 hours with specimen in test jig, then released and bent over 4-inch diameter mandrel.	3	0
					(OVER)	

16. SUMMARY OF REPORT, NATURE OF FAILURES AND CORRECTIVE ACTIONS TAKEN:

These qualification tests were performed on the CPS 796-80 polyurethane elastomeric product, type III in accordance with Specification MSFC-SPEC-202A with the following exceptions: (1) only samples of the two-part (A and B) kits were tested; (2) shelf life tests were not conducted; and (3) fungus and ozone resistance tests were waived. The series of tests have shown that the CPS 796-80 compound has met the requirements of the specification and is recommended for addition to the qualified products list (MSFC-QPL-202-2).

(OVER)

21. REPT. NO: 501.32.00.00

17. TESTED BEYOND VENDOR CATALOG SPECIFICATIONS	YES	18. VENDOR INFORMED OF TEST RESULT BY: LETTER	CY OF REPT	ORAL	19. SIGNED	20. CONTRACTOR	SUBCONTRACTOR
	X	X				NASA/MSFC	

IDEP FORM NO. 19 9-62

8. ITEM	8A. PART TYPE, SIZE, RATING, LOT, ETC.	9. VENDOR	10. VENDOR PART NO.	11. IND./GOV. STD. NO.	12. TOTAL TESTED
5					
6					
7					
8					

15A. ITEM	TEST OR ENVIRONMENT	C PER SPEC	D SPEC. PARAGRAPH/ METHOD/CONDITION	E TEST LEVELS, DURATION AND OTHER DETAILS	F NO. TESTED	G NO. FAILED
All	Temperature resistance	A	4.4.3.8	100 ± 1° C after 30-min conditioning period.	3	0
All	Tear resistance	A	4.4.3.10	Specimen cut with model C die and was torn in test jig at uniform 20 ± 1 inch travel rate.	3	0
All	Moisture resistance	A	4.4.3.11	Humidity chamber raised from 24 ± 1° C to 71 ± 1° C during 2-hour period @ 95% relative humidity. Conditions maintained 6 hrs. Next 16 hrs temp was dropped at a uniform rate to 24 ± 1° C. Five cycles were completed.	3	0
All	Tensile strength and elongation	A	4.4.3.12	Dumbbell specimens with bench marks ruptured at 20 ± 1 inch rate of travel.	3	0
All	Shrinkage	A	4.4.3.13	1 inch cube @ 23 ± 1° C was cooled and volume determined by water displacement.	1	0
All	Compression set	A	4.4.3.14	Specimen compressed 20 percent and placed in 70 ± 1° C oven for 22 hrs, and thickness measured.	2	0
All	Nonvolatile content	A	4.4.4.1	Sample was weighed & exposed to 82 ± 2° C for 24 hrs, then cooled and reweighed.	1	0
All	Viscosity	A	4.4.4.2	Viscosimeter with no. 7 spindle operated at 10 rpm at 24 ± 2° C temp.	1	0
All	Specific gravity	A	4.4.4.3	Specimen weighed in air and in distilled water on analytical balance.	2	0
All	Application life	A	4.4.4.4.1	A 250-gram specimen was placed in a standard 1/2-pt can with retaining flange	1	0

16. SUMMARY OF REPORT, NATURE OF FAILURES AND CORRECTIVE ACTIONS TAKEN:

21. REPT. NO: 501.32.00.00

IDEP FORM NO. 18 9-62

8 ITEM	8A. PART TYPE, SIZE, RATING, LOT, ETC.	9. VENDOR	10. VENDOR PART NO.	11. IND./GOV. STD. NO.	12 TOTAL TESTED
5					
6					
7					
8					

15A 8 ITEM	TEST OR ENVIRONMENT	C PER SPEC	D SPEC. PARAGRAPH/ METHOD/CONDITION	E TEST LEVELS, DURATION AND OTHER DETAILS	F NO. TESTED	G NO. FAILED
				removed. A viscosimeter with no. 7 spindle at 10 rpm operated for 50 min to deter-		
				mine consistency. Readings were made at 10-min intervals until 1,000 poises were		
				attained.		
All	Hardness	A	4.4.4.5	Durometer and timer used to record indentations in specimens.	5	0
All	Adhesion to metal	A	4.4.4.6.1	Two 1-inch wide strips of aluminum alloy coated with compound were cured at 82°C	1	0
				for 16 hrs. A 180°pull and separation rate 2 inches per minute was used to test speci-		
				men.		
All	Adhesion to rubber	A	4.4.4.6.2	A 6-inch piece of neoprene rubber 1.500 inches wide and 0.075 inch thick was	1	0
				secured in a mold which was filled with compound and a metal panel placed on it.		
				Specimen was cured and tested the same as adhesion to metal.		
All	Adhesion to vinyl	A	4.4.4.6.3	A 6-inch vinyl tube with a 0.500-inch diameter was split lengthwise, prepared, cured,	1	0
				and tested the same as adhesion to rubber.		

16. SUMMARY OF REPORT, NATURE OF FAILURES AND CORRECTIVE ACTIONS TAKEN:

21. REPT. NO: 501.32.00.00

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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Dissemination of said information does not imply verification or endorsement of information. The originator, in submitting the material, is acting in accordance with the requirements of his contract, and neither the originator nor the disseminator assumes any liability to parties adopting any product, process, or practice based upon the usage of the information.

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1. REASON FOR TESTS

These tests were performed to determine whether or not this product meets the qualification requirements of Specification MSFC-SPEC-202A, type III.

2. DESCRIPTION OF TEST SAMPLE

Coast Pro-Seal and Manufacturing Company, 19451 Susana Road, Compton, California, polyurethane elastomeric compound (CPS 796-80) type III is a high temperature resistant, flexible, potting and molding compound for encapsulating connectors, printed circuit boards, and compounds.

3. DISPOSITION OF SAMPLES

After qualification testing, the test specimens and associated test data were retained by R-ASTR-ESE.

4. NARRATIVE ABSTRACT, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Narrative abstract. - These qualification tests were conducted in accordance with Specification MSFC-SPEC-202A, type III with the following exceptions: (1) only samples of the two-part (A and B) kits were tested; (2) shelf life tests were not conducted; and (3) fungus and ozone resistance tests were waived.

4.2 Conclusions. - CPS 796-80 polyurethane elastomeric compound was qualification tested as specified herein and successfully met the applicable requirements of Specification MSFC-SPEC-202A, type III.

4.3 Recommendations. - It is recommended that CPS 796-80 polyurethane elastomeric product be added to the qualified products list (MSFC-QPL-202-2).

5. FACTUAL DATA

5.1 Description of test apparatus. - The following laboratory equipment was used in conducting the evaluation of CPS 796-80 compound:

Item	Manufacturer	Model no.
Analytical balance	Voland Corp.	Speedigram model 750-D; 1/20 milligram sensitivity at full load

Item	Manufacturer	Model no.
Arc resistance tester	Industrial Instruments, Inc.	Model ART-1
Bridge oscillator	General Radio Co.	1330-A
Capacitance bridge	General Radio Co.	Type 716-CSI
Compression device	MSFC	None
Dielectric sample holder	General Radio Co.	1690-A
Dielectric breakdown tester	Industrial Instruments, Inc.	Model PA 50-1005
Durometer	Shore Instrument and Manufacturing Co.,Inc.	A scale
High potential tester	Associated Research, Inc.	Model 4501 M18
Humidity test chamber	Tenney Engineering, Inc.	Model T3OURF-100500; range from minus 87 to plus 260 degrees C (minus 100 to plus 500 degrees F); 30 cubic foot capacity
Low temperature chamber	Tenney Engineering, Inc.	Model TSA12100
Megger	Freed Transformer Co., Inc.	Model 1620; 5 percent, all-range accuracy
Megohm bridge	Keithley Instruments, Inc.	515
Null indicator	General Radio Co.	1212-A

Tensile strength tester (elongation)	H. H. Scott, Inc.	Model CRE
Viscosimeter	Brookfield Engineering Laboratories, Inc.	Model RVF Synchro-lectric

5.2 Test Procedures.

5.2.1 Standard conditions. - Standard conditions are defined as 24 ± 2 degrees celsius (C) temperature and 50 ± 5 percent relative humidity. Unless otherwise specified herein, all tests were conducted at standard conditions.

5.2.2 Requirements. - The requirements for qualification testing of polyurethane elastomeric compound were as specified in Specification MSFC-SPEC-202A, type III, except as indicated in 4.1. Specific data obtained from this series of tests are included in table I.

5.2.3 Dielectric constant and power factor. - Three disc-shaped specimens, 2 inches in diameter and 0.125 inch thick, were prepared in accordance with the manufacturers' specifications and cured at 82 degrees C (180 degrees Fahrenheit) for 16 hours. The test apparatus consisted of a bridge oscillator, capacitance bridge, null indicator, a micrometer-driven dielectric sample holder, and appropriate charts and tables. The oscillator was adjusted to 1 megahertz (MHz) output, and the sample holder was attached to the direct jacks of the capacitance bridge. The test specimen was placed in the holder and the electrode spacing adjusted to the release point, then backed off to a firm hold. The holder cover was closed, and the micrometer reading was recorded as T_1. The capacitance and dissipation dials were adjusted for maximum dip of the null indicator and recorded as C_1 and D_1. The specimen was then removed from the holder, and a new maximum null dip was determined for the air equivalent by adjusting the electrode spacing and dissipation dials. The capacitance was not changed, and the readings were recorded as T_2 and D_2. Specification MSFC-SPEC-202A requires that the dielectric constant not exceed 5, and that the power factor not exceed 0.09. The test results, as recorded in table I, were calculated as follows:

(a) Capacitance.

$$Cx = Ca2 + \Delta CA2 - Ca1$$

Cx = equivalent series capacitance of specimen
Ca2 = geometric air capacitance at T_2 from table
ΔCA2 = correction for setting T_2 from chart
ΔCa1 = correction for setting T_1 from chart

NOTE

Since the size of the specimen and the size of the electrode were the same, the term $Ca1\left[1 - \frac{Ax}{Ae}\right]$, which equaled zero, was not used in this calculation.

(b) Dielectric constant.

$$K = \frac{Cx}{Ca1}$$

K = dielectric constant
Cx = equivalent series capacitance of specimen
Ca1 = correction for setting T_1 chart

(c) Power factor. - The power factor differs negligibly from the dissipation factor and was calculated as follows:

$$PF = D_X = (D_1 - D_2)\frac{C1}{Cx}$$

PF = power factor
D_X = calculated dissipation value
D_1 = dissipation dial reading with test specimen installed in test fixture
D_2 = dissipation dial reading (air equivalent) with test specimen removed from test fixture
C_1 = capacitance dial reading with test specimen installed in test fixture
Cx = calculated capacitance value

5.2.4 Dielectric strength. - Five disc specimens, 4 inches in diameter and 50 mils thick, were prepared in accordance with 5.2.3. The electrodes were polished brass discs, 2 inches in diameter and 1 inch thick. A dielectric breakdown tester equipped with a high voltage transformer rated at 50 kilovolts

maximum output was used for the test which was conducted with the specimen immersed in an oil bath at standard temperature conditions. The test voltage was applied to the brass electrodes and increased from zero to breakdown at a uniform rate of 500 volts per second (Vps) on each of the 5 specimens. Specification MSFC-SPEC-202A requires that the dielectric strength be 500 volts per mil thickness. The test results are recorded in table I.

5.2.5 Volume resistivity.-Three disc specimens, 4.0 inches in diameter and 0.125 inch thick, were prepared in accordance with 5.2.3. The test apparatus consisted of a 3-electrode system, a 500 volt direct current (Vdc) megohm bridge, and appropriate switches and keys. The electrodes were brass which had been polished to a mirror finish. The volume resistivity was measured, using a completely guarded circuit. Electrode no. 1, used as the guarded electrode, was connected to the megohm bridge measuring terminals. Electrode no. 2, used as the guard electrode, was connected to the bridge guard terminal. Electrode no. 3, used as the unguarded electrode, covers the entire bottom surface. Voltage was applied for 1 minute to the specimens, and the volume resistivity was recorded. Specification MSFC-SPEC-202A requires that the volume resistivity not drop below 1×10^{12} ohms/centimeter at ambient temperature. The test results, as recorded in table I, were calculated as follows:

$$VR = \frac{A}{t} R_V$$

VR = volume resistivity in ohms per centimeter
t = average thickness of specimen
Rv = volume resistance measured by the instrument
A = effective area calculated from dimensions of electrode system as $A = \frac{DO^2}{4}$ where $DO = \frac{D_1 + D_2}{2}$ as in figure 1

5.2.6 Surface resistivity.-Three disc specimens, 4.0 inches in diameter and 0.125 inch thick, were prepared as specified in 5.2.3. The test apparatus consisted of a 3-electrode system, a 500 Vdc megohm bridge, and appropriate switches and keys. The electrodes were brass which had been polished to a mirror finish. The surface resistivity was measured, using a completely guarded circuit. Electrode no. 1 was used as the guarded electrode, no. 3 was used as the guard electrode, and no. 2 was used as the unguarded electrode. Voltage was applied for 1 minute to the specimens, and the surface resistivity was recorded. Specification MSFC-SPEC-202A

requires a surface resistivity of 1×10^{12} ohms. The test results, as recorded in table I, were calculated as follows:

$$\rho = \frac{p}{g} Rs$$

ρ = surface resistivity
Rs = surface resistance in ohms
g = distance between electrodes 1 and 2
p = effective perimeter of the guarded electrode where
p = πDO and DO = dimensions in figure 1

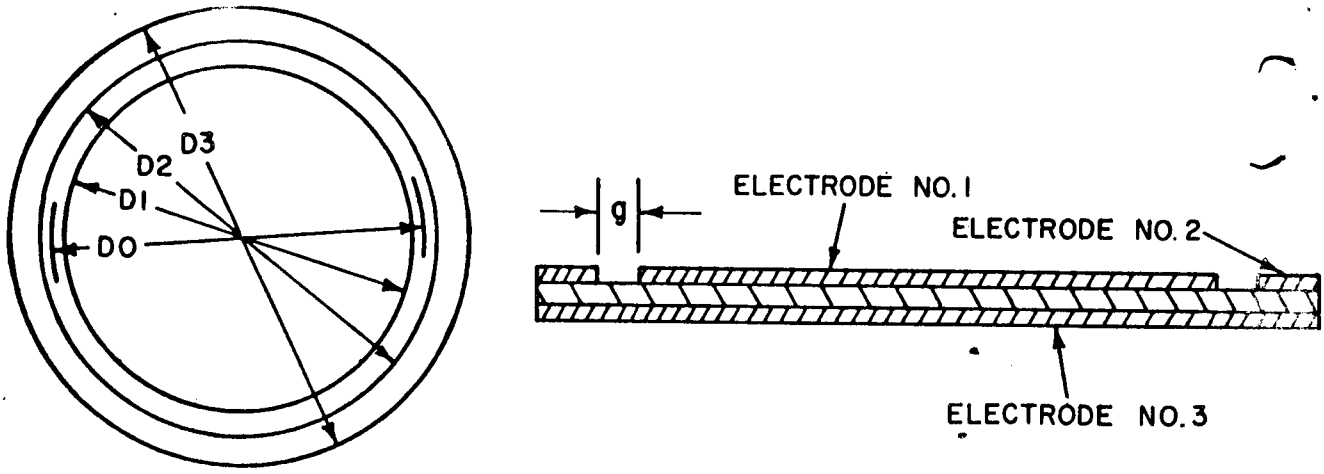

Figure 1. Trielectrode arrangement for volume and surface resistivity test.

5.2.7 Arc resistance. - Three disc specimens, 4 inches in diameter and 0.125 inch thick were prepared as specified in 5.2.3. The test apparatus consisted of the electrical components necessary to produce a high voltage, low current arc at automatic timed intervals of 1 minute in interrupted steps indicated as follows:

10-milliamp arc applied for 1/8 of a 2-second cycle
10-milliamp arc applied for 1/4 of a 2-second cycle
10-milliamp arc applied for 1/2 of a 2-second cycle
10-milliamp arc applied continuously
20-milliamp arc applied continuously
30-milliamp arc applied continuously
40-milliamp arc applied continuously

Each specimen was placed in the test apparatus in such a manner as to allow the weighted electrodes to make firm contact with the specimen. Tests of smooth, dust free specimens were conducted at standard conditions on five different locations. Specification MSFC-SPEC-202A requires that the specimens withstand a high voltage, low current arc for a period of 45 seconds. Results of the above tests are recorded in table I.

5.2.8 Insulation resistance. - Three specimens with brass rod electrodes, 0.125 inch in diameter and 3 inches long, were cast in a cylindrical mold in such a manner that 1.500 inches of the length of each pair of electrodes was embedded in the compound. Measurements were made with a megohm bridge at 500 volts (V) potential for a period of 2 minutes. Tests were conducted at 24 ± 1 and 100 ± 1 degrees C after a conditioning period of 30 minutes at test temperature. Specification MSFC-SPEC-202A requires that the specimens have a minimum insulation resistance of 100,000 megohms (1×10^{11} ohms) at ambient temperature and 750 megohms (7.5×10^{8} ohms) at 100 degrees C. The test results are recorded in table I. See figure 2 for insulation resistance test setup.

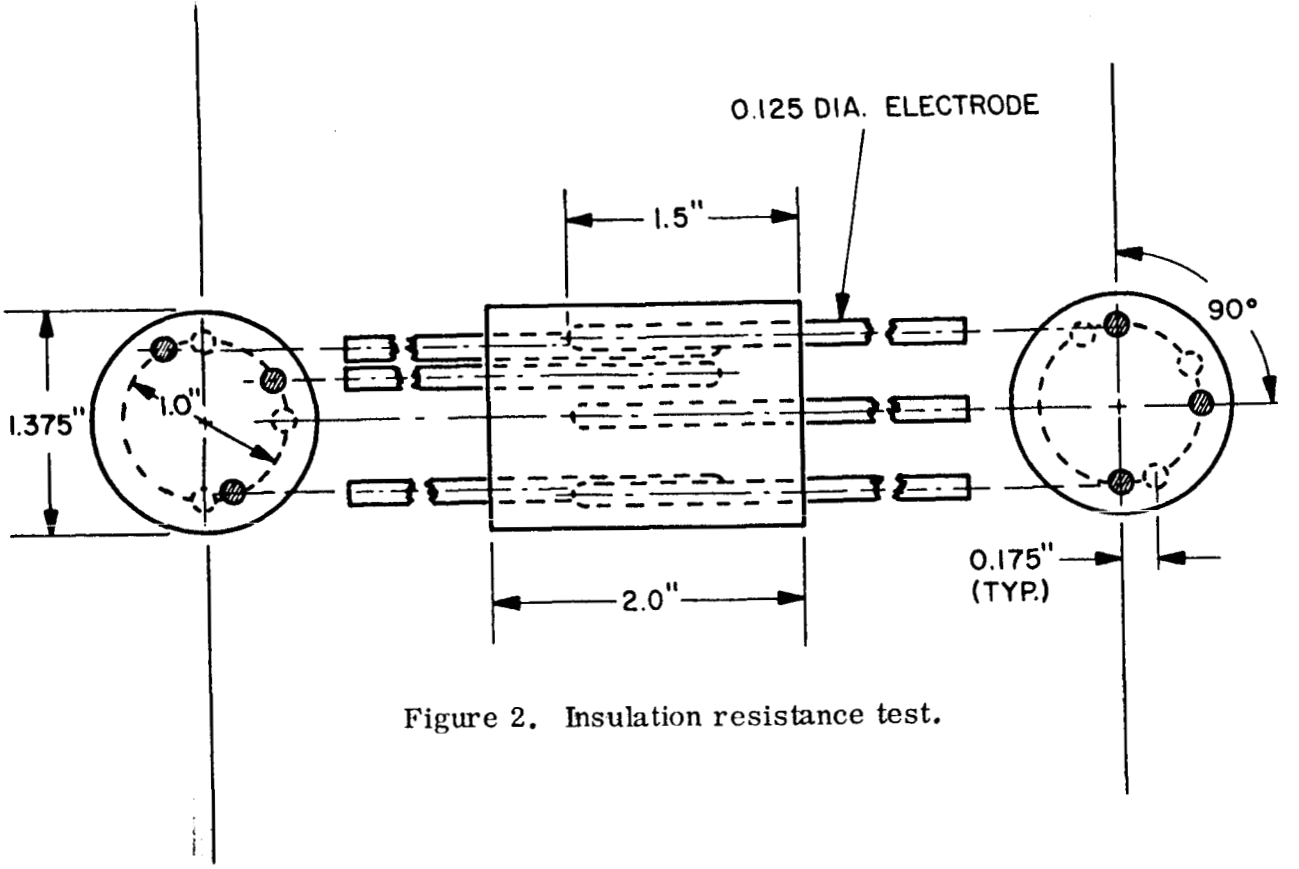

Figure 2. Insulation resistance test.

5.2.9 High potential resistance. - A potential of 1,000 V root mean square (rms) at 60 hertz (Hz) was gradually applied to the electrodes for 1 minute per pair at the rate of 500 Vps. Test specimens were the same as in 5.2.8. Specification MSFC-SPEC-202A requires that the test specimens withstand without breakdown a potential of 1,000 V rms at 60 Hz, for a period of 1 minute, applied at a rate of 500 Vps. Results of this test are recorded in table I.

5.2.10 Low temperature flexibility. - Three pieces of aluminum alloy 1 by 0.032 inches were coated with a recommended primer on one side. The compound was applied on the primed side producing cured coatings 0.050 to 0.066 inch thick with 1 inch at each end of the specimen uncoated. These were inserted in a flexibility jig with the uncoated side contacting the contour block and the weight contacting the uncoated end. The flexibility jig and specimens were conditioned to a temperature of minus 55 ± 1 degrees C for 4 hours when the specimens were bent over the curved portion of the test jig by releasing the fastening hook. The specimens were then removed and examined. Specification MSFC-SPEC-202A requires that the test specimens not crack nor separate when they are subjected to a temperature of minus 55 degrees C for a minimum of 4 hours and tested as specified above. Results of the tests are recorded in table I.

5.2.11 Temperature resistance. - The temperature resistance was determined in accordance with 5.2.5 except the tests were conducted after a conditioning period of 30 minutes at 100 ± 1 degrees C. Specification MSFC-SPEC-202A requires that the specimens have a volume resistivity of 1×10^9 ohms per centimeter when they are subjected to a temperature of 100 ± 1 degrees C. Results of this test are recorded in table I.

5.2.12 Tear resistance. - Three specimens conforming to the size and shape shown in the following diagram were cut with a model C die from molded sheets of compound and secured in the test apparatus as described in 5.2.14. See figure 3 for tear resistance test setup.

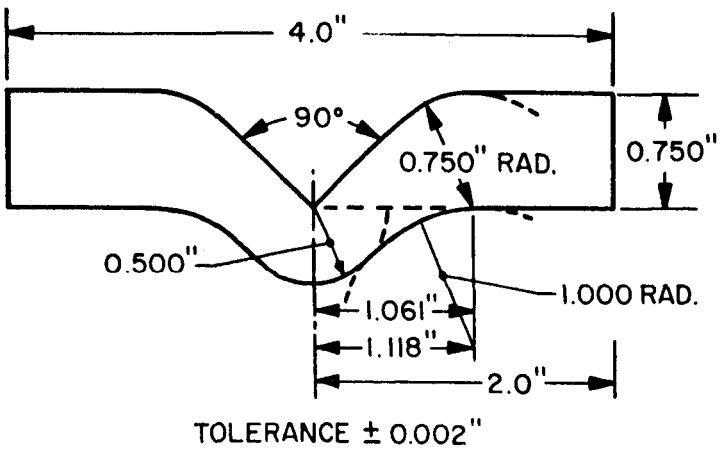

Figure 3. Tear resistance test.

The test apparatus was switched on, and the power actuated grips traveled at a uniform rate of 20 ± 1 inches per minute until the specimen was torn. Upon tearing the specimen, tear value was recorded. Specification MSFC-SPEC-202A requires that the specimens have a tear resistance of 250 pounds per inch, minimum. Results of this test, as recorded in table I, were calculated as follows:

$$TR = \frac{F}{T}$$

TR = tear resistance in pounds per inch of thickness
F = maximum tearing force in pounds
T = thickness of the specimen in inches

5.2.13 Moisture resistance. - Three specimens, as specified in 5.2.8, were placed in a test chamber at 24 ± 1 degrees C and 95 percent relative humidity. The chamber temperature was raised uniformly throughout a 2 hour period to 71 ± 1 degrees C with relative humidity maintained at 95 percent. These conditions were maintained for 6 hours. During the next 16 hours, the chamber temperature was reduced uniformly to 24 ± 1 degrees C. This completed one cycle. The test consisted of five cycles after which the specimens were tested as specified in 5.2.8. Specification MSFC-SPEC-202A

requires that the specimens have an insulation resistance of 200 megohms (2×10^8 ohms) minimum when tested as specified above. Results of this test are recorded in table I.

5.2.14 Tensile strength and elongation. - Three dumbell-shaped specimens, 4.500 inches long by 1 inch wide on the enlarged ends, and 0.2500 inch wide by 1.3125 inches long in the reduced area, were cut from a molded sheet of compound, 6 by 6 inches and 0.0800 inch thick, that was prepared and cured in accordance with the manufacturers' specifications under standard conditions. In addition, two parallel benchmarks were placed symmetrically on the reduced section of the specimen perpendicular to the longitudinal axis by means of a bench marker and ink. The benchmarks were 0.0100 inch wide and the distance between them was 1 inch. This measurement is recorded as D. The test apparatus consisted of a power-driven machine capable of 20 ± 1 inch rate of travel; a device to automatically record the tensile strength in pounds per square inch required to force the specimen to break; a scale to read the distance between the bench marks at the time of rupture and holding grips of the type that tighten automatically as the pull force is increased. The specimen was secured in the holding grips, the machine switched on, and the rate of travel continued until the specimen broke. The breaking force in pounds was recorded as F, and the distance between the benchmarks recorded as D_1. Specification MSFC-SPEC-202A requires that the specimens have a minimum tensile strength of 2,500 pounds per square inch (psi). The test results, as recorded in table I, were calculated as follows:

(a) Tensile strength.

$$T = \frac{F}{C}$$

T = tensile strength
F = the breaking force in pounds
C = the cross sectional area of the unstretched specimen in square inches

(b) Elongation.

$$E = \frac{D_1 - D}{D} \times 100$$

E = percent elongation
D_1 = the distance between the benchmarks in inches at the time of the tear
D = the distance in inches between the knife edges of the marker

5.2.15 Shrinkage. - A 1 inch cubical mold with an open top was used for the test. The volume of the mold was determined at 23 ± 1 degrees C. The compound was then cast in the mold and cured in accordance with the manufacturer's instructions. The specimen was cooled to 23 ±1 degrees C, examined, and the volume determined by the water displacement method. The percent of shrinkage was calculated as follows:

$$\text{Percent shrinkage} = \frac{V_1 - V_2}{V_2} \times 100$$

V_1 = volume of the mold and V_2 = final volume of specimen

5.2.16 Compression set. - Two cylindrical discs, 0.500 inch thick and 1.125 inches in diameter, were molded and cured for 16 hours at 82 degrees C and compressed 20 percent. The test apparatus was a compression device as shown in figure 4.

The disc specimens were placed between the polished steel plates of the compression device, with the spacers on each side of it. Bolts of the device were tightened so that the plates were drawn together uniformly until they were in contact with the spacers. The steel spacers were of the same thickness as the specimen after the specimen had been compressed 20 percent. The test device was then placed in an air circulating oven at 70 ± 1 degrees C for 22 hours. The specimens were removed from the oven and were allowed to cool for 30 minutes. A dial gage with a raised platform and presser foot, 0.375 and 0.250 inch in diameter, was used to measure the final thickness. Specification MSFC-SPEC-202A requires that compression set of the specimens

not exceed 35 percent. Figure 4 shows the compression set test setup. Results of this test, as recorded in table I, were calculated as follows:

$$C = \frac{t_o - t_{30}}{t_o - t_s} \times 100$$

C = compression set expressed as percentage of original deflections
t_s = thickness of the spacer bars
t_{30} = thickness of the specimen 30 minutes after removal from compression
t_o = original thickness of the specimen

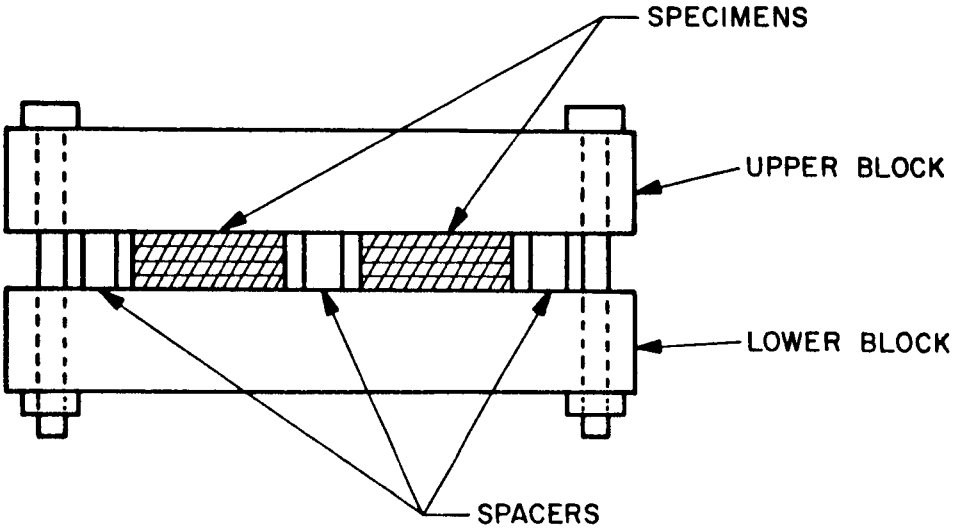

Figure 4. Compression set test.

5.2.17 Nonvolatile content. - Fresh compound was poured, level with the rim, into tared containers 1.750 inches diameter and 1.250 inches deep. The specimens were weighed, placed in an oven at 82 ± 2 degrees C for 24 hours, removed from the oven, cooled to room temperature, and reweighed. Nonvolatile content was calculated by multiplying the last weight by 100 and dividing the results by the first weight. Specification MSFC-SPEC-202A requires the minimum nonvolatile content be 99 percent by weight. Results of this test are recorded in table I.

5.2.18 Viscosity. - A thoroughly mixed specimen was tested with a viscosimeter equipped with a number 7 spindle, and operated at 10 revolutions per minute while being subjected to a uniform 24 ± 2 degrees C temperature.

Recordings were made when the pointer first assumed a steady position after release of the clutch. Specification MSFC-SPEC-202A requires that the viscosity be 100, minimum, to 300, maximum, poises. Results of this test are recorded in table I.

5.2.19 Specific gravity. - Four specimens, weighing approximately 1 gram, were cut from a sheet of compound that was molded and cured in accordance with the manufacturer's specification. The test apparatus consisted of an analytical balance and weights; a length of wire, approximately 0.004 inch in diameter; ethyl alcohol, 95 percent; distilled water; and absorbent paper. Tests were conducted at 25 ± 0.5 degrees C. The specimen was weighed in air on the analytical balance and weight recorded as W_1. The wire for suspending the specimen was attached to one arm of the balance and was weighed in distilled water; weight was recorded as W_2, while noting the depth the wire was immersed. The specimen was then dipped in alcohol, blotted with absorbent paper, and suspended from the balance arm, by means of the wire, to the same depth. Specification MSFC-SPEC-202A requires that the specimens not exceed a specific gravity of 1.1. Results of this test, as recorded in table I, were calculated as follows:

$$SG = \frac{W1}{W1\ (W3-W2)} \times 0.9971$$

W1 = weight of the specimen in air (grams)
W2 = weight of the support wire in distilled water (grams)
W3 = weight of the specimen and supporting wire in distilled water (grams)

5.2.20 Application life. - A 250-gram sample of compound was used to determine application life, which started at the end of the mixing period. A standard 1/2-pint can with its retaining flange removed was used in conjunction with a viscosimeter, equipped with a number 7 spindle, which was operated at 10 revolutions per minute in order to mix the compound. Consistency was determined at the end of a 50-minute period. Readings were recorded at 10 minute intervals until a reading of 1,000 poises was attained, which was considered the end of the application life test. Readings were recorded when the pointer on the viscosimeter dial first assumed a steady position after more than 3 revolutions. Specification MSFC-SPEC-202A requires that the compound be suitable for application for a minimum of 60 minutes. Results of the test are recorded in table I.

5.2.21 Hardness. - Five disc-shaped specimens, 0.750 inch in diameter, were cut from a sheet of molded compound 0.250 inch thick. The test apparatus was a durometer consisting of a presser foot pierced by a hole 0.125 inch

in diameter, the center of which was not closer than 0.250 inch to the edge of the presser foot in any direction; an indenter point made of hardened steel to operate through the hole in the presser foot; a calibrated spring that will force the indenter point to extend from the face of the presser foot as far as permitted by the test specimen; an indicator gage dial on which the amount of extension of the indenter point beyond the face of the presser foot is read in terms of gradations ranging from 0, for full extension, to 100, for zero extension; and a timer that indicated time in seconds. The specimen was placed on a firm, smooth surface and the durometer was lowered with sufficient pressure to insure firm contact of the presser foot with the specimen. The indentation reading was made immediately upon firm contact between presser foot and the specimen, and the value recorded to the nearest whole scale unit. Specification MSFC-SPEC-202A requires that the specimens have a Shore A hardness of 76 to 99 after full cure. Results of this test are recorded in table I.

5.2.22 Adhesion to metal. - A 3- by 6-inch aluminum alloy panel, approximately 0.062 inch thick, was cleaned with methyl ethyl ketone and wiped dry with clean cotton gauze sponges. One surface of the panel was coated with a thin layer of primer and allowed to dry for 60 minutes. A 0.125 inch coating of compound was applied to the primed panel and a 3- by 6-inch area of a 3- by 12-inch strip of cotton duck fabric also coated with compound was applied. The panel was then cured at 82 ± 2 degrees C for a 16 hour period. Two strips 1 inch wide were cut through the fabric and compound to the panel surface and extended the full length of the loose end of the fabric. The specimen was placed in the grip attachments of the test machine described in 5.2.14 and a 180-degree pull with a jaw separation rate of 2 ± 0.125 inches per minute was applied to measure the adhesion strength in pounds per inch width. Specification MSFC-SPEC-202A requires that the compound have a minimum adhesion bond strength of 15 pounds per inch when applied to metal. Results of this test are recorded in table I.

5.2.23 Adhesion to rubber. - A 6-inch piece of neoprene rubber 1.500 inches wide and 0.075 inch thick was buffed on one side with an abrasive to break the surface, cleaned with methyl ethyl ketone, and dried with an air pressure hose. The neoprene was placed cleaned side down on a mold, secured with masking tape, and the assembled mold cavity filled to a slight crown with compound. A metal panel, cleaned and primed, was placed on top of the mold which was cured at 82 ± 1 degrees C for a 16-hour period. The specimen was allowed to cool for 12 hours at room temperature and was tested as specified in 5.2.22. Specification MSFC-SPEC-202A requires that the compound have a minimum adhesion bond strength of 15 pounds per inch when applied to rubber. Results of this test are recorded in table I.

5.2.24 Adhesion to vinyl. - A 6-inch piece of vinyl tubing, 0.500 inch in diameter, was split lengthwise, made tacky by applying methyl ethyl ketone, coated with a layer of primer, and allowed to become tacky free. The specimen was then prepared and tested in the same manner as described for neoprene rubber in 5.2.23. Specification MSFC-SPEC-202A requires that the compound have a minimum adhesion bond strength of 15 pounds per inch when applied to vinyl. Results of this test are recorded in table I.

5.3 Test results. - Polyurethane elastomeric compound 796-80, type III sucessfully met all the requirements stated in Specification MSFC-SPEC-202A and is recommended for addition to the qualified products list. (See table I for test results.)

5.4 Test data. - Results of the specified test requirements for the polyurethane elastomeric compound are presented in table I. The sequence of tabulation, along with Specification MSFC-SPEC-202A specific requirements by paragraph, is designed to facilitate data support referencing.

Table 1. Test data

Test	MSFC-SPEC-202A requirements	Results	MSFC-SPEC-202A paragraph reference	
Dielectric constant	5 max	4.08	3.5	4.4.3.1
Power factor	0.09 max	0.037	3.5	4.4.3.1
Dielectric strength	500 volts/mil thickness, max	524.6 volts/mil thickness	3.5	4.4.3.2
Volume resistivity	1×10^{12} ohms/cm, min	6.2×10^{12} ohms/cm	3.5	4.4.3.3
Surface resistivity	1×10^{12} ohms, min	2.9×10^{14} ohms	3.5	4.4.3.3
Arc resistance	45 seconds, min	124 seconds	3.5	4.4.3.4
Insulation resistance	1×10^{11} ohms, min	6.3×10^{11} ohms	3.5	4.4.3.5
(23° C) (100° C)	7.5×10^{8} ohms, min	1.2×10^{9} ohms	3.5	4.4.3.5
High potential resistance (60 Hz/1minute)	no breakdown	0.005 ma (no less)	3.5	4.4.3.6
Low temperature flexibility	see MSFC-SPEC-202A	Acceptable	3.4.5	4.4.3.7
Temperature resistance (100° C)	1×10^{9} ohms/cm, min	5.1×10^{10} ohms/cm	3.5	4.4.3.8
Tear resistance	250 pounds per inch	329 pounds per inch	3.5	4.4.3.10
Moisture resistance	2×10^{8} ohms, min	1.4×10^{9} ohms	3.4.7	4.4.3.11
Tensile strength	2,500 psi	2,805 psi	3.5	4.4.3.12
Elongation	300 percent	475 percent	3.5	4.4.3.12
Shrinkage (volume)	3 percent, max	2.8 percent	3.5	4.4.3.13
Compression set	35 percent, max	29.9 percent	3.5	4.4.3.14
Nonvolatile content	99 percent, min	99.9 percent	3.3.3	4.4.4.1
Viscosity	100 to 300 poises	120 poises (after 30 minutes)	3.5	4.4.4.2
Specific gravity	1.1, max	1.1	3.5	4.4.4.3
Application life	60 minutes, min	65 minutes	3.4.2.1	4.4.4.4.1
Hardness (Shore A)	76 to 99	83	3.5	4.4.4.5
Adhesion to metal	15 pounds per inch, min	36 pounds per inch	3.5	4.4.6.1
Adhesion to neoprene	15 pounds per inch, min	29 pounds per inch	3.5	4.4.6.2
Adhesion to vinyl	15 pounds per inch, min	16 pounds per inch	3.5	4.4.6.3

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